text or computer generated images, so including such formats will stifle the development of educational, scientific, and other services that seek to incorporate both video images and computer-based information.

In the first place, the Grand Alliance HDTV system emphasizes progressive scan, utilizing progressive scan for five of the six HDTV formats. All material originally produced on film, including all motion pictures and approximately 80 per cent of today's prime time television programming, will always be transmitted using progressive scan. Other video material such as news and sports programs may or may not be broadcast in progressive scan at the discretion of the broadcaster. In addition, all of the HDTV formats, including the single interlaced format, are square pixel formats, an important characteristic for facilitating interoperability with computers.[12] The SDTV transmission formats proposed by the Advisory Committee also stress progressive scan, comprising nine of the twelve SDTV formats in the ATSC DTV Standard.[13] This means broadcasters and others can easily use progressive scan transmission formats for program material where it offers better performance, or for applications that use text and graphics, or for other video that is likely to be viewed on computers.

In the second place, most of these parties confuse transmission formats with display formats that may be implemented in receivers. In a digital system, transmission and display formats are no longer linked and need not be the same.[14] The expressed concerns center around display formats, yet it is the transmission standard and not a display standard that is at issue before the Commission. Some recognize this, but argue that transforming interlaced

---

or rationale to converge their positions and every proposed format in the Grand Alliance proposal has supporters and detractors."

[12]"Square pixels" means that picture elements are equally spaced in the vertical and horizontal direction, a condition that simplifies computer processing of images.

[13]Thus, 14 of the 18 DTV formats are progressive scan formats.

[14]On June 25, 1996 Lucent Technologies and Mitsubishi announced an agreement to develop a set of semiconductor chips that will perform all of the functions needed for next-generation high-definition television sets for the U.S. market. One of the five application-specific integrated circuits being developed is a display processor, which transforms decoded video signals into various display formats.

signals into progressive signals at the receiver is an imperfect and expensive solution. However, these concerns are greatly overstated. Advisory Committee tests of the Grand Alliance prototype system demonstrated conclusively that de-interlacer performance is essentially transparent,[15] and the cost of receiver de-interlacers was a concern of several parties until a cost study undertaken by the Advisory Committee concluded that the concern was unwarranted.[16,17]

Finally, although the ATSC members generally agree that progressive scanning is the *preferred* mode for text and graphics material, we do not agree that interlaced scanning is *inadequate* for services involving computer-based information, even where signals are transmitted *and* displayed in interlaced format. Perhaps because some computer applications in the past rendered text and graphics inadequately by not including proper anti-aliasing techniques, interlaced scanning was given a bad reputation in the computer industry. As the Grand Alliance demonstrated conclusively at the Commission's December 1995 *En Banc* Hearing, small-sized text can be delivered with crispness and clarity even when it is compressed, transmitted, and displayed in interlaced format. Moreover, several computer companies have recently announced joint ventures involving the provision of information services using DBS and other television delivery media. These ventures all utilize interlace scan, and presumably offer acceptable performance.[18]

---

[15]*See* Record of Test Results, *digital* HDTV Grand Alliance System, October 1995, at page III - 45.
[16]One of the members of ATSC has worked with a major computer manufacturer to develop a single integrated circuit that converts among a wide variety of current video formats, including the ATSC DTV Standard formats. This chip has shown superb performance in private demonstrations, and will soon be announced publicly.
[17]Perhaps understanding that even if all transmission formats were progressive, some consumers might still find interlaced displays attractive, some but not all of the members of the computer industry raising these complaints have called for the Commission to ban interlace formats in all ATV *displays*. This proposal violates a long-standing, widely supported computer industry policy opposing government regulation of the features of consumer electronics products. Moreover, banning interlace displays would deprive consumers of the option to purchase less expensive receiver models using such displays, an option that may be attractive to many consumers.
[18]For example, Compaq and Thomson Consumer Electronics recently announced joint development of a TV/PC product, illustrating that even the analog, interlaced NTSC transmission standard is not an overwhelming impediment to the potential convergence between PCs and television receivers. Further, Microsoft and DirecTV have announced their cooperation for the delivery of computer content via the

Ignoring the benefits that interlaced scanning can provide for many types of traditional television programming would unduly limit applications of proven importance to broadcasters and viewers. For the vast amount of archival video material originally produced using interlaced scanning, broadcasters will generally find it more efficient to transmit using an interlaced format, and during the transition period broadcasters may prefer an interlaced transmission format for some DTV/NTSC simulcast material. While interlace scanning may not be optimum for computer text and graphics applications, it can deliver good performance for such applications if implemented correctly. Indeed, in today's analog television system, interlaced scanning delivers text and graphics required for broadcast programs effectively every day. Interlaced scanning has a long track record of proven value and successful use in traditional television broadcasting, and it has many staunch defenders. In addition, broadcasters must be concerned about the interoperability of a DTV transmission standard with currently available HDTV production equipment and with the installed base of NTSC production and studio equipment, virtually all of which employ interlaced scanning. Furthermore, in the case of SDTV where the objective may be to transmit multiple programs simultaneously over a 6 MHz channel, for non-film-based video, the use of interlace scanning will generally permit more simultaneous programs to be carried than if progressive scanning is used.[19,20]

DirecTV DBS system, again showing that the predominant use of interlaced formats in the DirecTV system has not proven to be a barrier to TV and computer company collaboration to deliver content. When adoption of the ATSC DTV Standard makes both progressive and interlaced formats available to deliver these types of applications, the marketplace will dictate which formats are most advantageous for which applications.

[19] Thus, for certain types of low-budget programs likely to be produced in SDTV video and broadcast during non-prime time hours, e.g., education programs, children's programs, public access programs, local public affairs programs, high school sporting events, etc., prohibiting interlaced transmission formats would reduce the number of such programs that could be transmitted simultaneously by a local broadcaster.

[20] Accordingly, William Schreiber is mistaken in claiming that the introduction of a progressive scan HDTV camera removes the last remaining argument for including an interlaced format in the digital broadcast television standard. (*See* letter of William F. Schreiber to Chairman Hundt, May 9, 1996.) While the introduction of such a product is an important and welcome development, it does not negate the substantial benefits, outlined above, of including interlaced scanning formats in the ATSC DTV Standard.

In evaluating pleas to ban interlaced transmission formats from the ATSC DTV Standard, the Commission must bear in mind that with today's technological limitations such an action would mean that a 720-line format would be the only format for HDTV live video programs. There is a substantial body of broadcasters and others who believe that a high-definition format must have more than 1,000 lines to be successful. Any action to eliminate the 1080-line interlaced HDTV format from the proposed standard would cause a substantial loss of industry support for the overall DTV proposal. Moreover, it is ironic that the proposed ATSC DTV Standard is the *only* digital television development effort in the world that stresses interoperability with computers and telecommunications, e.g., by primarily using progressive scan and square pixels. If the Commission were to delay adoption of the Advisory Committee recommendation out of a concern with interlaced scanning, it would only serve to entrench interlaced scanning as the predominant mode for digital television throughout the world.[21]

Regardless of the technical arguments about the acceptability of interlaced formats for certain classes of applications, continued insistence on *banning* interlaced formats is unwarranted. The ATSC DTV Standard contains numerous progressive scan and square pixel formats to support the applications that benefit from those attributes.[22] Neither program producers, broadcasters, nor consumers will be forced to *use* an interlaced format simply

---

[21]In response to the development of all-digital HDTV broadcast systems in the U.S. first announced in 1990, the Digital Video Broadcasting ("DVB") Project was formed in Europe in 1993 and has since developed a family of digital television standards for satellite, cable, terrestrial and other delivery media. The project has expanded around the world, and now has over 200 members in 29 countries, including Apple Computer and many other U.S. computer, telecommunications, and consumer electronics companies. DVB Satellite services began in 1995 and are currently being used in Europe, Africa, Asia, North America and Australasia. DVB Cable services commenced operation in Europe and Australia in 1995, and DVB Terrestrial services are expected to begin in 1997 in Europe. Current DVB standards focus on SDTV, using interlaced scanning formats and non-square pixel arrays. Likewise, efforts to date to develop and offer satellite and cable digital television services in the U.S. have focused on SDTV, using interlaced scanning and non-square pixel arrays.
[22]As Chairman Wiley noted in his December 1995 *En Banc* Hearing testimony, "Fortunately, the Grand Alliance technology is flexible enough to incorporate both scanning modes in the standard (at minimal additional cost). There was overwhelming consensus for this approach, which reasonably meets the needs of all affected parties. Conversely, there was absolutely no record of support for dropping either mode." (emphasis in original)

because it exists in the standard. On the other hand, there is no doubt that broadcasters will transmit tremendous amounts of material using progressive scan -- motion pictures and most prime time programming at a bare minimum. And for non-film-based video, if judged superior by the marketplace, the use of progressive scan transmission formats will surely proliferate. Likewise, progressive scan displays will predominate among consumers if they offer better price/performance characteristics. Indeed, several members of the ATSC who manufacture televisions already plan to include progressive scan displays in their initial ATV product offerings, and some broadcasters have stated that they are leaning toward the use of progressive scan transmission formats for HDTV.[23]

Some members of the computer industry have also complained about the 60 Hz transmission rate, again confusing transmission formats with display formats. For example, Apple states ". . . the proposed *transmission rate* of 60 Hz is of particular concern. A 60 Hz *display rate* has not proven to be sufficient for the display of text and fine graphic information with the resolution expected by computer users."[24] These complaints are unwarranted from any perspective.

From a broadcaster and regulatory perspective, a 60 Hz transmission rate is certainly adequate to ensure smooth motion rendition in transmitted signals, which is the extent to which a transmission standard should concern itself with either source or display picture refresh rates. Further, the adoption of a higher frame rate than 60 Hz would have to come either at the expense of reduced spatial resolution or increased compression artifacts in order to continue to fit the coded signals within a 6 Mz terrestrial channel, neither of which is a desirable alternative.

---

[23]ABC, a member of ATSC, has expressed a tentative preference for progressive scan transmission, however, ABC sees value in the interlaced formats, especially for transmitting material from the immense archives of video originally produced with interlaced scanning. ABC strongly supports rapid adoption of the ATSC DTV Standard, including all of the formats contained therein.

[24]Fourth NPRM Comments of Apple Computer at 7 (emphasis added).

From a television receiver perspective, it will be possible to make receivers with higher display refresh rates if the marketplace warrants the additional expense. However, a 60 Hz display rate is not a problem for traditional television viewing of typical motion video material, which will continue to comprise the bulk of DTV viewing use. Further, a 60 Hz display rate is not likely to be a problem for still images with text and fine graphic information, given the greater viewing distances and lower lighting levels that are associated with a television viewing environment (as opposed to an office/desktop environment).

From a computer perspective, computers (or televisions used in computing applications) are not prevented from using conversions to display the transmitted signal at any desired rate. For still pictures, the screen can easily be refreshed at any high rate desired, as is done today. For the display of motion video in a computer, it is possible easily and accurately to convert 60 Hz DTV signals into a 72 Hz display rate by employing the same frame rate conversion techniques commonly used to convert 50 Hz PAL and SECAM television around the world to 60 Hz NTSC television used in North America and Japan.[25] Further, motion pictures and the majority of prime time programming are produced in 24-frames-per-second film, which in DTV will be transmitted directly at the 24 Hz rate, which is easily converted to a 72 Hz display rate. (Indeed, the simplicity of this conversion is the motivation for the selection of 72 Hz by its proponents.)

Finally, in all events, the Commission should not regulate the features or performance of displays, as the computer industry has long held.[26]

The Commission's overriding goal in this proceeding is to preserve and enhance free over-the-air television service, including the adoption of policies that will allow digital television infrastructure and applications to contribute to improving the NII. Contrary to the

---

[25]Conversion from 60 to 72 Hz requires a 5:6 frame rate conversion, the same as required for the conversion of 50 to 60 Hz. (i.e., 60:72 = 50:60 = 5:6).

[26]In addition to the ability of the proposed standard to handle text and fine graphics even with interlaced transmission formats, it should be noted that some text and graphics will be coded and carried over the channel as data, not as video images.

implicit assumption of some members of the computer industry, the Commission's goal *is not* and *should not* be to make the digital HDTV receiver -- already the most computer-friendly, interoperable entertainment/NII appliance ever developed -- indistinguishable from a desktop personal computer.

B. Aspect Ratio

Some cinematographers have objected to the 16:9 aspect ratio included in the ATSC DTV Standard, saying that it will limit broadcasters' ability to display the full artistic quality of their work. As explained fully in the August 28, 1995 letter of Stanley Baron, President of the Society of Motion Picture and Television Engineers, and also head of the ATSC Technology Group on Distribution (T3),[27] this decision was reached more than a decade ago after extended and careful deliberations with extensive participation by the motion picture and television production community. The final 16:9 ratio (1.78:1) was in fact wider than the 5:3 ratio originally sought by the electronics manufacturing industry, and utilizes three-quarters of the total screen height for 2.4:1 material (the widest of the commonly used motion picture aspect ratios) and three-quarters of the screen width for 4:3 material (the standard NTSC format).

The 16:9 aspect ratio has been adopted by a variety of international standards bodies, and manufacturers around the world have been building CCD sensing arrays, camera lenses, production equipment, picture tubes, and widescreen receivers in the 16:9 format for years. Because of the wide variety of aspect ratios used by the motion picture industry in the United States and throughout the world, and because an aspect ratio wider than 16:9 is not ideal for some other types of programming such as newscasts and one-on-one interviews, it is impossible to select a single aspect ratio that perfectly satisfies every need. However, as Mr. Baron's letter makes clear, it has been demonstrated that there is no difficulty in accommodating program material or motion picture films of any reasonable aspect ratio within

[27]*See* NPRM at ¶50, fn 44.

the 16:9 format either for production, post-production, distribution or display. Changing the aspect ratio for broadcast DTV at this late date would cause unacceptable and unnecessary delays in implementing DTV service, would severely damage many parties who have already made significant investments leading to DTV service, and ironically would entrench the current 4:3 aspect ratio in new non-terrestrial broadcast digital television services.[28]

C. Interoperability with Cable and Other Delivery Media

Although the Advisory Committee's charter was to recommend a *terrestrial broadcast* ATV transmission standard, from the beginning the easy interoperability of the broadcast ATV standard with cable TV systems was a key objective in the development of the Grand Alliance system and the ATSC DTV Standard. Indeed, the Grand Alliance developed and evaluated high-data-rate modes, i.e., 16-VSB and 256-QAM, for possible use in cable and other transmission environments that can support higher data rates than terrestrial broadcast. This capability would be utilized to deliver approximately twice the payload capacity achievable over 6 MHz terrestrial channels. Accordingly, such capabilities could support, for example, two simultaneous live-action HDTV sports programs over a single 6 MHz cable channel.

Throughout the nine-year Advisory Committee process, the cable industry has made significant investments and contributions to ensure the suitability of the standard for carriage over cable systems. A significant portion of the Advisory Committee's laboratory and field tests were conducted by Cable Television Laboratories, Inc. ("CableLabs"), including testing of the selected 16-VSB mode. The testing focused on ensuring that the digital HDTV system developed for terrestrial broadcast would also meet the needs of the cable industry. As a result, the ATSC members believe that as voluntary standards activities continue in the cable

---

[28] *See* Mark Shubin, "The History of the Perfect Aspect Ratio," Proceedings of the 137th SMPTE Technical Conference and World Media Expo, September, 1995, finding, *inter alia,* that there is no perfect aspect ratio, but if there were, it would be 16:9; that the 16:9 ratio has already been chosen and is in use around the world; that 16:9 should only be changed for compelling reasons and his research has found none.

industry,[29] as well as for DBS, MMDS and ITFS services and open video systems, it is likely that many elements of the terrestrial ATV standard will also be incorporated in emerging standards in these industries. We believe that such voluntary standards would promote the early availability of digital television, including HDTV, over all of these other media as well as terrestrial broadcasts, without causing undue burdens on cable operators or other providers.

VI. Other Issues

A. Receiver Standards

In the NPRM at ¶66 the Commission inquires whether it should require that receivers (and set-top boxes designed to receive ATV broadcasts for display on NTSC sets) be able to receive adequately all DTV formats. In comments on the Fourth NPRM, receiver manufacturers stated their belief that marketplace forces would dictate that all DTV receivers (and set-top converters) would be capable of *receiving* all DTV formats, although some receivers might well *display* high-definition signals in a lesser resolution format.[30] In comments on the Fourth NPRM and in public comments that have followed, including Congressional testimony, broadcasters have made clear that they intend to broadcast substantial amounts of HDTV programming over their DTV channels. It would be foolhardy for any manufacturer to offer digital sets in the marketplace that go dark for any programming, much less a substantial amount of broadcast programming. Consequently, the statements of manufacturers and broadcasters alike clearly suggest that digital receivers will have all-format reception capability with or without any government mandate to do so.

---

[29]For instance, the Society of Cable Television Engineers has recently launched a digital television standards engineering subcommittee.

[30]In ¶66, the NPRM cites concerns that an all-format reception requirement might have a large effect on either reception quality or receiver costs, somehow attributing these concerns to the Electronic Industries Association and its Advanced Television Committee (EIA/ATV) and to Zenith Electronics Corporation. In fact, neither EIA/ATV nor Zenith expressed any such concerns, but both parties expressed the belief that digital sets would receive all of the digital formats without any Commission mandates. (*See* Fourth NPRM Comments of EIA/ATV at 15 and Comments of Zenith at 4.)

With respect to other aspects of the reception performance of receivers, the broadcaster members of ATSC are particularly anxious to ensure that the actual performance of receivers is adequate to obtain the coverage predicted by the models used in allotting and assigning digital broadcast channels. The receiver manufacturer members of ATSC share this concern, but point out that the same marketplace forces that operate today to ensure that television manufacturers provide adequate reception performance will motivate manufacturers to compete to provide high-quality receivers.

The ATSC has recently charged its newly-formed Implementation Subcommittee, which includes both broadcasters and receiver manufacturers, to investigate whether receiver performance standards need to be defined to satisfy these concerns. If the Subcommittee determines that such standards are required, it will work with the Consumer Electronics Manufacturers Association (one of the founding members of the ATSC) to ensure that such standards are developed expeditiously. If it is determined that minimum performance levels need to be established for DTV receivers, it is vital that the development of such standards not delay the adoption by the Commission of the ATSC DTV Standard. Whether any such standards are the subject of voluntary industry standards, or whether the Commission finds it appropriate and necessary to codify an industry recommendation into its rules, the Commission need not and must not delay adoption of the transmission standard itself.

B. Licensing of Technology

As the Commission notes in ¶67 of the NPRM, the Advisory Committee's testing procedures required that the proponents of any DTV system agree (a) to make a license available without compensation to applicants desiring to utilize the license for the purpose of implementing the standard, or (b) to make a license available to applicants under reasonable terms and conditions that are demonstrably free of any unfair discrimination. To this end, as part of its effort to establish and document the DTV standard, ATSC sought and obtained from each member of the Grand Alliance and from Dolby Laboratories in February 1995 a written commitment to abide by this requirement. Furthermore, we believe that pending patents of these entities would fall under the same reasonable and nondiscriminatory licensing requirement. The ATSC is not aware of any problems that would require the Commission to take further action to ensure easy and nondiscriminatory access to the intellectual property necessary for a rapid implementation of the ATSC DTV Standard.

C. International Trade

As the Commission has noted (NPRM, ¶68), the Advisory Committee and the Grand Alliance took great pains to maximize compatibility with international standards, including the use of MPEG-2 video compression and MPEG-2 transport. Providing compatibility for these two elements is most important in providing a high degree of international interoperability. It is less important and less likely that some other aspects of the system, such as the modulation scheme and the picture refresh rate be common among all nations or regions. Beyond these structural commonalities, expeditiously authorizing a single DTV standard for use in the United States will *enhance* the export opportunities of U.S.-based content providers and equipment manufacturers, because the focus by broadcasters, manufacturers and consumers on a single well-defined standard will promote a rapid introduction of the service, which in turn will promote its use in other countries around the world. Indeed, the most important thing the Commission can do to facilitate international compatibility and to promote export opportunities is to adopt the ATSC DTV Standard as rapidly as possible.

As discussed previously, the ATSC has recently modified its charter to permit parties throughout North and South America and the Caribbean with an interest in digital television to become members. ATSC also has other activities under way to promote the use of the ATSC DTV Standard beyond the U.S., especially throughout the Americas. We believe that the ATSC DTV Standard represents the best digital television technology in the world, fully encompassing both HDTV and SDTV as well as a host of other applications, and offers by far the best interoperability with computers and telecommunications, through its use of a packetized data transport structure and its emphasis on progress scanning and square pixels.

Yet, while this superior system awaits final approval from the Commission, the European DVB system -- which presently implements only SDTV using interlaced scanning and non-square pixels exclusively -- has been adopted and mandated in Europe and is being heavily promoted around the world, and has even been selected for use in some U.S. DBS services. Moreover, efforts to promote the ATSC DTV Standard for use elsewhere in the world encounter the obvious obstacle that it still has not been adopted for terrestrial television in the United States.[31]

Just as certainty and reliability are required to galvanize the industry toward implementing digital broadcast television, such certainty and reliability are necessary to motivate other countries to utilize the ATSC DTV Standard for terrestrial television, or to motivate parties here and abroad to implement all or part of the standard for nonterrestrial applications. Notwithstanding the broad industry consensus supporting the ATSC DTV Standard, further delays by the Congress and the Commission threaten to squander the technological lead that the U.S. fought so hard to achieve and see the U.S. "re-leap-frogged" in exploiting this innovative American-born technology.

D. Captioning

The Decoder Circuitry Act of 1990 directed the FCC to establish rules to ensure that closed captioning decoders were provided in television receivers, and specifically to ensure that such capability was made possible for ATV services then on the horizon. Under the Commission's rules adopted pursuant to this law, all television receivers 13" and above must include closed captioning capability. Over the course of the last several years, the Advisory

[31]One bright spot has recently developed in this otherwise discouraging international scene. Following the Commission's tentative decision in this proceeding to adopt the ATSC DTV Standard, in June 1996, the Digital Audio/Visual Council ("DAVIC") selected the ATSC DTV video and audio specifications as the basis for the DAVIC 1.2 standard for "higher quality video and audio." DAVIC is a non-profit association based in Geneva, Switzerland, with more than 200 member companies in more than 25 countries, aimed at promoting the success of digital audio/visual applications and services based on specifications that maximize interoperability across countries and across applications and services. Further success in promoting the ATSC DTV Standard in DAVIC and in other international settings will require continued clear signals and expectations that the standard will indeed be formally adopted by the Commission for use in the U.S.

Committee and ATSC have worked closely with the affected communities to ensure that closed captioning needs were fully addressed in the standard to be proposed to the Commission so that receiver manufacturers could reliably build closed captioning capability into their ATV receiver designs. We believe that the proposed ATSC DTV standard fully provides all the capability necessary for broadcasters and receiver manufacturers to provide closed captioning.

E. Content Advisory Information

As previously noted (*see* fn 6, *infra*), the ATSC is providing technical assistance to the cross-industry task force that is developing a voluntary program rating system that would utilize the V-chip capability mandated by the Telecommunications Act of 1996. The flexibility inherent in the packetized data transport structure of the ATSC DTV Standard ensures that such program rating information can be easily incorporated into digital broadcasts. Once the cross-industry task force has completed its work, the ATSC will spell out the details for incorporating this capability into the standard.

VII. Conclusion

The ATSC DTV Standard represents by far the world's best digital broadcast television system, with unmatched flexibility and unprecedented ability to incorporate future improvements. Implementing this technology will dramatically raise the technical quality of broadcast television, helping to preserve for consumers and for our democratic society the benefits of a vibrant and healthy free over-the-air television service in the years and decades to come. In addition, deploying this technology will enable consumers to access a host of potential information services that can help meet pressing needs in health, education and other aspects of our society, and will create and preserve tens of thousands of high-skill, high-wage jobs and engender substantial economic growth for our nation.

Over the past decade, the Commission has championed a unique process, providing policy direction and support, while relying on private investment, competition and a volunteer army of experts and leaders from the affected industries to develop a stunning technological achievement. Through this thorough, open, and extended process, an extremely broad consensus has been achieved throughout the affected industries, delicately balancing the needs of consumers and the various industries involved. In sharp contrast, there is no consensus supporting the changes proposed by the few detractors of the proposed standard.

Now it is time for the Commission to act decisively, to follow through on the commitment it has made to industry repeatedly over the past decade to set a new broadcast television standard. The ATSC members implore the Commission to adopt the full ATSC DTV Standard as swiftly as possible and mandate its use by digital broadcast licensees. In so doing, the Commission will provide the certainty and reliability required by financiers, broadcasters, manufacturers and consumers to unleash the further substantial investments necessary to bring the benefits of this fertile technology to the American public and to spread those benefits throughout the world.

Respectfully submitted,

Robert K. Graves

Robert K. Graves
Chairman

Mark Richer

Mark S. Richer
Executive Director

Advanced Television Systems Committee
1750 K Street, NW, Suite 800
Washington, DC 20006
(202) 828-3130
(202) 828-3131 (fax)
http://www.atsc.org

July 11, 1996

APPENDIX A: ATSC MEMBERSHIP LIST

ADVANCED TELEVISION SYSTEMS COMMITTEE

MEMBERS

AT&T
Baylor University - Telecommunications
Bell Communications Research
CBS Broadcast Group
Cable Television Laboratories
Capital Cities/ABC
Consumer Electronics Manufacturers Association
David Sarnoff Research Center
Digital Multimedia Compression, Inc.
Dolby Laboratories, Inc.
Eastman Kodak Company
Florida Atlantic University
Fox Inc.
GTE Telephone Operations
General Instrument Corporation
Hitachi America, Ltd.
Home Box Office
Ikegami Electronics USA, Inc.
Institute of Electrical & Electronics Engineers
Intel Corporation
Koichi Sadashige & Associates
Lucent Technologies
MIT Advanced TV & Signal Processing Group
Maximum Service Television
Mitsubishi Consumer Electronics America
Motion Picture Association of America
National Association of Broadcasters
National Broadcasting Company
National Cable TV Association
Panasonic ATVL
Panasonic Broadcast Systems Company
Philips Electronics North America Corp.
Pioneer New Media Technologies, Inc.
Public Broadcasting Service
SBCA
Scientific Atlanta
Sharp Electronics Corporation
Snell & Wilcox
Society of Motion Picture & Television Engineers
Sony Advanced Systems Company
Sony Pictures Entertainment
TV/COM International
Tektronix, Grass Valley Products
Tele-TV Systems
Texas Instruments
Thomson Consumer Electronics
Titan Information Systems
Toshiba America Consumer Products, Inc.
Tribune Broadcasting Company
Universal City Studios, Inc.
VLSI Technology Inc.
Viacom International Inc.
Zenith Electronics Corporation

OBSERVERS

Argonne National Laboratory
Asia-Pacific Broadcasting Union (ABU)
Canadian Broadcasting Corporation (CBC)
ETRIUS
European Broadcasting Union (EBU)
Federal Communications Commission
NASA
The White House
US Army Night Vision and Electronic Sensors
US Department of State

APPENDIX B: PROTECTION FROM INTERFERENCE

A. Emission Mask (¶56)

ATSC proposes a specification for a rigid emission mask that is somewhat different from that proposed by the Commission, and also encourages consideration of an alternative mask based on a weighting function that can be determined from interference data taken at ATTC. The ATSC-proposed rigid mask is defined in terms of Desired-to-Undesired ratio (D/U) and a 500 kHz measurement bandwidth. This definition specifically recognizes that the required attenuation of ATV spectral sidelobes depends on the relative power levels of the ATV signal and an NTSC signal in the adjacent channel over the ATV coverage area. The alternative proposal, which ATSC prefers, bases the out-of-band specification on a weighting function for the effect of noise on an NTSC signal.

RIGID MASK SPECIFICATION:

We believe that the following specification captures the Commision's intent and also includes the effects of the 500 kHz measurement bandwidth and the "smearing" effect of the measurement bandwidth at the channel band edge.

Out-of-band emissions of an ATV transmitter as measured in a 500 kHz bandwidth centered Δf MHz from the edge of the assigned channel shall be attenuated below the average ATV transmitted power output according to the following schedule:

(a) For 0.25 MHz $\leq \Delta f \leq$ 6 MHz:

$$\text{Attenuation in dB} = 58 + \left(\frac{D}{U}\right)_{db} + \frac{(\Delta f)^2}{1.44}$$

(b) For $\Delta f \geq 6$ MHz:

$$\text{Attenuation in dB} = 83 + \left(\frac{D}{U}_{db}\right)$$

WHERE:

Δf is the deviation in MHz of the *center* of the 500 kHz measurement bandwidth from the edge of the assigned ATV channel

and

$$\left(\frac{D}{U}\right)dB = 10\log_{10}\left(\frac{\textit{Average Power of the ATV Signal}}{\textit{PK. Sync Power of Adj. channel NTSC Signal}}\right)_{MAX}$$

i.e., the maximum ratio of received ATV power compared to an adjacent NTSC channel power at any location within the ATV coverage area where the NTSC channel's coverage must be protected. This D/U ratio is -12 dB for equal coverage, collocated ATV and NTSC stations.

ALTERNATIVE TO A RIGID MASK SPECIFICATION: WEIGHTING FUNCTION

The mask given above is sufficient to guarantee proper coexistence of ATV and adjacent channel NTSC. Nevertheless, an alternative "weighting function" approach has merit and is recommended by ATSC. This approach allows some flexibility in spectral sidelobe details not permitted under the rigid mask specification, while still achieving completely adequate protection of adjacent channels.

This approach is based upon measurements made at the ATTC to determine NTSC's Threshold of Visibility (TOV) for 500 kHz wide noise sources centered at various points across the NTSC channel. This work determined an appropriate weighting function, which is rounded to the nearest dB to obtain this alternative specification.

Additional work done at ATTC showed that noise with a flat spectrum across the 6 MHz NTSC channel which has a power that is at least 51 dB below NTSC peak of sync was adequate to avoid TOV interference with the NTSC signal. Weighting such a flat spectrum of noise with the weighting function results in a weighted TOV power level which is 5 dB lower, or at 56 dB below NTSC peak of sync power.

For various shaped noise distributions across the NTSC channel, it has been verified that as long as the weighted noise is at least 56 dB below NTSC peak-of-sync power, then TOV is avoided. Here, the NTSC noise interference is viewed as arising from the spectral sidelobes of an adjacent channel ATV transmitter. If the ratio of ATV average power to NTSC peak-of-sync power is $\left(\frac{D}{U}\right)_{dB}$, then to avoid NTSC TOV the ATV sidelobes in the adjacent NTSC channel, when weighted and summed across the channel, must be attenuated below average ATV transmitter power by at least $\left(56+\left(\frac{D}{U}\right)_{dB}\right)$ dB. For example, *in the collocated, equal coverage DTV/NTSC/NTSC case*, $\left(\frac{D}{U}\right)_{dB}$ = -12 dB, so the weighted ATV sidelobe power in an adjacent channel needs to be attenuated at least 56 - 12 = 44 dB below average ATV signal power for this collocated case.

Further work done at the ATTC determined that in order to avoid the Threshold of Audibility (TOA) on the NTSC audio channel, the power measured in the upper 500 kHz segment of the NTSC channel must be attenuated at least 48 dB below NTSC peak of sync power, or 48 + $\left(\frac{D}{U}\right)_{dB}$ dB below the ATV average power. This was for a ratio of audio-to-video carrier powers of -13 dB. Proportionally less attenuation is required for higher audio-to-video ratios.

The protection of the adjacent NTSC channel against TOV and TOA leads to the following alternative out-of-band ATV spectral emission regulation:

(a) To protect against adjacent channel NTSC TOV, out-of-band ATV spectral emissions measured in an adjacent 6 MHz wide channel, when weighted by the weighting function, shall be attenuated below the ATV average transmitter power by at least 56 + $\left(\frac{D}{U}\right)_{dB}$ dB.

(b) Additionally, to protect against adjacent channel TOA, the power measured in the uppermost 500 kHz segment of an adjacent channel shall be attenuated below ATV average power by at least 48 + $\left(\frac{D}{U}\right)_{dB}$ dB. This assumes an audio-to-video carrier power ratio of -13 dB.

(c) Finally, the weighted power in any non-adjacent 6 MHz channel shall be attenuated below ATV average power by at least 56 + $\left(\frac{D}{U}\right)_{dB}$ dB in that non-adjacent channel.

WHERE:

$$\left(\frac{D}{U}\right)dB = 10\log_{10}\left(\frac{Average\ Power\ of\ the ATV\ Signal}{PK.\ Sync\ Power\ of\ Adj.\ channel\ NTSC\ Signal}\right)_{MAX}$$

i.e., the maximum ratio of received ATV power compared to an adjacent NTSC channel power at any location within the ATV coverage area where the NTSC channel's coverage must be protected. This D/U ratio is - 12 dB for equal coverage, collocated ATV and NTSC stations.

This alternative regulation based on the weighting function avoids a slavish adherence to a rigid mask's detailed sidelobe requirements and instead substitutes a requirement leading to adequate TOV protection of the adjacent channel based upon the weighted noise power caused by the ATV sidelobes in the adjacent channels. This reasonably relaxes the burden on manufacturers to produce ATV transmitters which can coexist with adjacent channel NTSC without unduly focusing on unimportant fine-structure details of the spectral sidelobes as can occur with a rigid mask specification.

B. <u>Frequency Offsets</u> (¶57)

ATSC believes that in selecting the ATV frequency assignments there are several interference mechanisms that must be considered. These are (1) ATV-to-ATV co-channel, (2) NTSC-to-ATV co-channel, and (3) ATV-to-NTSC upper adjacent channel. Other interference effects (i.e., lower adjacent, taboos, ATV-to-NTSC co-channel, etc.) are insensitive to frequency offset. In each case, the dominant interference will determine which frequency offset will have precedence. The ATV offsets in each case below track the assigned offsets to the NTSC station (i.e., -10 kHz, 0 kHz, + 10 kHz).

These proposed offsets are not intended as modifications to the ATSC Standard. Rather, these offsets are specific solutions that account for interference effects encountered during the actual channel allocation process.

CO-CHANNEL ATV-TO-ATV OFFSET RECOMMENDATION

In the ATV co-channel interference condition, it has been found that an ATV frequency offset that is an odd multiple of half the ATV segment rate provides improved interference rejection. There are several choices that meet this requirement. An offset of 1.5 times the segment frequency (i.e., 19,403 Hz) appears to provide the best performance. The frequency tolerance of the ATV transmitters is ± 10 Hz.

CO-CHANNEL NTSC-TO-ATV OFFSET RECOMMENDATION

For the NTSC-to-ATV co-channel interference condition, the best performance is obtained if the ATV signal is aligned such that the NTSC visual carrier is located near the notch of the receiver comb filter. Additionally, the ATV receiver clock recovery performance is most robust if the visual carrier location is chosen to be near an odd multiple of half of the segment frequency. It has been shown that the choice that places the ATV pilot below the NTSC visual carrier by 70.5 times the segment frequency (i.e., 911,944 Hz) provides the best performance. This has a tolerance of ±1 kHz.

UPPER ADJACENT CHANNEL ATV-INTO-NTSC OFFSET RECOMMENDATION

For interference caused by the upper adjacent ATV-into-NTSC, tests at the ATTC have shown that the ATV pilot carrier may appear as a chrominance beat in the NTSC image on some sets. An improved alignment between the ATV pilot and the NTSC chroma subcarrier is selected to be an odd multiple of half the NTSC line rate. This causes the chrominance beat pattern to alternate at the NTSC line rate. This reduces the visibility of the chroma beat interference. The offset proposed by the ATTC is 95.5 times the NTSC horizontal rate. This allows a tolerance of ±1 kHz on both the NTSC and ATV transmitters. The frequency of the ATV pilot can be expressed in terms of the frequency of the NTSC visual carrier on the lower channel and the NTSC horizontal rate.

$$F_p(n) = F_v(n-1) + \frac{455}{2} F_h + 9.55 F_h$$

The ATTC found that when this frequency is chosen as the offset, an underlying high-frequency luminance beat of 5.0821678 MHz is also then produced. This interference was most visible during the ATTC test since only a pilot carrier, and not the full ATV signal was tested. The ATTC has proposed an additional refinement to the offset between the ATV and NTSC signals to produce an alternating beat pattern at both the NTSC frame and line rates. This proposal specifies a difference between the ATV pilot and the NTSC chroma carrier of 95.5 times the NTSC line rate minus the NTSC frame rate.

$$F_p(n) = F_v(n-1) + \frac{455}{2} F_h + 95.5 F_h - 29.97$$

This additional refinement provides a further reduction in visibility of upper adjacent ATV interference into NTSC, but it requires a tighter frequency control on the NTSC transmitter to maintain a frequency difference within ±3 Hz.

C. <u>Power Measurements</u> (¶58)

ATSC proposes that the average power of the transmitted signal be specified and measured as follows:

The present NTSC service allows a power variation ranging between 80% and 110% of authorized power. These values correspond to -0.97 dB and +0.41 dB respectively. Because of the so-called "cliff effect" at the fringes of the service coverage area for an ATV signal, the allowable lower power value will have a direct effect on the ATV threshold. A reduction of 0.97 dB in transmitted power will change the ATV threshold of 14.9 dB (which has been determined to cause a 3×10^{-6} error rate) to 15.87 dB, or approximately a one mile reduction in coverage distance from the transmitter. It is proposed that the lower allowed power value be 95% of authorized power and that the upper allowed power value be 105% of authorized power.

A conventional full-wave rectifier type of power meter will register approximately 1 dB lower than the true power on "white" noise. It has not been determined what the reading will be when measuring ATV power, but it is likely to be different than with "white" noise. It is suggested that ATV stations use a calorimeter type true power measurement method to re-calibrate the rectifier type of power meter if used. The power reading should have an uncertainty no worse than 5%, and preferably better, in order to have minimum impact on ATV coverage.

Measurements made on the 8 VSB signal with a commercial rectifier type watt meter indicate 1 dB higher power values than the actual power. A transmitter measured with such a watt meter will provide approximately 1 mile less coverage than the authorized power would allow.

It is proposed that the quality of the emitted signal be specified and measured by determining the departure from 100% eye opening. This departure, or error, is made up of three components: 1) circuit or "white" noise; 2) intermodulation noise caused by non-linearities; and 3) intersymbol interference; and is measured and specified by an error vector magnitude.

An error vector magnitude of minus 27 dB relative to the authorized power will reduce the ATV threshold by 0.25 dB, or approximately 1/4 mile in coverage distance from the transmitter.